SOLAR RADIATION MEASUREMENTS OBTAINED AT THE BLUE HILL METEOROLOGICAL OBSERVATORY OF HARVARD UNIVERSITY DURING THE SECOND INTERNATIONAL POLAR YEAR, AUGUST 1932 TO AUGUST 1933

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[Harvard University, Blue Hill Observatory, Milton, Mass., September 1933]

Soon after my retirement from the United States Weather Bureau on June 30, 1932, Dr. Charles F. Brooks, director of the Blue Hill Observatory, asked me to outline a program of solar radiation meaurements for the observatory. Since local conditions seemed favorable, and no systematic series of solar radiation intensity measurements had ever been made in New England, I suggested that the polar-year program as outlined by the International Commission for Solar Radiation be followed as completely as the facilities of the Observatory would permit. This suggestion was adopted, and steps were at once taken to equip the observatory with the following instruments:

(1) A Smithsonian silver-disk pyrheliometer, S.I. no. 63, which was to be used as a substandard instrument.

(2) A 10-junction thermoelectric pyrheliometer, Weather Bureau type, as modified and manufactured by the Eppley Laboratory.

(3) A four-junction thermopile of the Coblentz type, also manufactured by the Eppley Laboratory, mounted in an enclosed box at the lower end of a diaphragmed tube and supported on a telechron-driven equatorial mounting to keep the tube accurately pointed toward the sun. A second and longer tube of heavy cardboard, afterwards replaced by a tube made of galvanized iron, enclosed the smaller diaphragmed tube and shielded it from the wind which sometimes is disturbingly high on the top of Blue Hill, and especially so on top of the observatory tower.

Frequent slight hand adjustments of the tube are necessary to insure accurate pointing.

(4) A set of standard yellow and red glass screens, furnished by the Potsdam, Germany, Magnetic Meteorological Observatory, which were cut from the same pieces of Schott glass as were similar screens furnished to observatories in Europe, and to the United States Weather Bureau. The mean transmission coefficients for these screens have been published in the Met. Zeit., 1932, Heft 6, S. 242–244. Recent tests made at the United States Bureau of Standards, and at the Fixed Nitrogen Laboratory of the United States Department of Agriculture, indicate that the screens furnished the United States Weather Bureau and the Blue Hill Observatory transmit only 0.992 as much as is indicated by the published mean coefficients, due to their cutting off all radiation at a slightly higher wave length (0.004μ) than is given for the mean.

(5) A Leeds & Northrup micromax continuously recording millivoltmeter, with full-scale deflection equaling 5.0 millivolts.

(6) An Engelhard recording microammeter, with full scale deflection equal to 15.0 microamperes, and contacting once a minute.

The color screens are mounted on the tube containing the four-junction thermopile in such a way that the thermopile may receive the unobstructed radiation from the sun, or the radiation transmitted by the red or the yellow screen as is desired. At first these intensities were recorded on the Engelhard recorder, which was of the multiple recording type. The record was not entirely satisfactory, as under the most favorable conditions the individual printing arms did not print dots in a straight line, but in a succession of steps, covering somewhat more than one space on the record sheet, representing a variation of 0.15 microampere. For this reason the thermopile, on May 6, 1933, was connected with the Leeds & Northrup recording millivoltmeter.

At the same time the 10-junction thermoelectric pyrheliometer, which had been recording on the Leeds & Northrup millivoltmeter, was shifted to the Engelhard multiple recorder, which, in the course of a few weeks was exchanged for a single register of the same type, contacting every 30 seconds.

The program of measurements of the intensity of the total solar radiation at normal incidence, I_m, and of the screened intensities, I_y, I_r, has been as follows:

On mornings when the sky is free from clouds in the vicinity of the sun, the cap is removed from the end of the diaphragmed tube above the 4-junction thermopile, the tube is carefully alined on the sun by means of ordinary sights, the telechron drive on the equatorial mounting is set in motion, as is also the recorder in the office room below. At about the same time the Smithsonian pyrheliometer is exposed on a stand on the flat roof of the observatory tower, where the 4-junction thermopile also is exposed.

The Smithsonian instrument is read for a period of 10 or 14 minutes which gives a series of 2 or 3 values of the intensity of the solar radiation at normal incidence. Usually during this same time interval the 4-junction thermopile is exposed to the sun alternately unscreened and with the yellow or the red glass interposed, each exposure being 3 to 4 minutes in length.

In this way, from at least one reading of the series a comparison is obtained between unscreened measurements of the intensity of solar radiation by the Smithsonian pyrheliometer, expressed in heat units (gr. cal/min/cm ^{2}), and by the thermopile, expressed in scale divisions on the record sheet. From comparative readings of this kind obtained at intervals throughout the day, and on all days when sky conditions were favorable, the value of scale divisions on the record sheet have been determined in the above-named heat units. This value has been used to reduce not only the unscreened, but also the screened records of solar radiation to standard heat units. Generally, only slight variations in the reduction factors thus determined have been found from day to day.

On July 19, however, after making the usual adjustments on the 4-junction thermopile, and reading the Smithsonian pyrheliometer, the observer left the recording apparatus in operation—as usual, to go to breakfast. When he returned, he found the air over the observing tower filled with flying ants, some of which had found their way into the diaphragmed tube, and onto the blackened receiving surface of the thermopile. It was therefore necessary to return the thermopile to the Eppley Laboratory for repairs, which resulted in the loss of screened solar-radiation records until August 6.

The radiation intensity measurements obtained as indicated above are given in table 1, columns 4, 5, and 6. They may be used to determine coefficients of atmospheric turbidity, as Ångström[1] has pointed out. In a later publication it is my intention to give such determinations

[1] Ångström, Anders. Atmospheric transmission of sun radiation. Geografiska Annaler, vol. 12, 1930, pp. 130–159.

by a modification of Ångström's method, which has already been outlined in the MONTHLY WEATHER REVIEW, 61:80–83, March 1933.

The total solar radiation received on a horizontal surface from the sun and sky, as measured by the Eppley 10-junction thermoelectric pyrheliometer, which is exposed on the south side of the parapet of the observatory tower, and is in continuous operation, has been summarized in the form of average daily totals for each week, and are given in table 2. The calibration constants accompanying the pyrheliometer, and which depend upon the calibration of a similar pyrheliometer by the U.S. Weather Bureau, have been employed in making the reductions to standard units.

No special difficulty is experienced in determining the hourly averages and the daily totals of solar radiation when the sky is either clear, or covered with a uniform cloud sheet; but when floating clouds of considerable density are numerous the radiation intensity often oscillates rapidly between slightly above zero to slightly above the intensity with a clear sky. In general, therefore, it is customary to determine the average intensity in scale divisions during each 20-minute interval, add together the averages for three of these intervals, and multiply the sum by 20 times the value of a scale division in standard heat units (gr. cal/min/cm^2), as derived from the calibration constants furnished with the instrument after adaptation, if necessary, to the register employed.

The observatory was fortunate in obtaining the services of Miss Harriet Steele, an expert mathematician and statistician, in making these rather tedious reductions.

Most of the Smithsonian pyrheliometric readings, and the records of total and screened solar radiation intensities obtained by means of the 4-junction thermopile, are due to Dr. C. F. Brooks, Director of the Observatory, Mr. E. Monroe Harwood, and Mr. Harry Wexler. The reduction of these records from automatic instruments to heat units, the determination of the apparent time of observations and records of solar radiation intensity from apparent noon, and the corresponding solar altitude and air mass, have mostly been determined by the writer.

TABLE 1.—*Total (I_m) and screened (I_y, I_r) solar radiation intensity (normal incidence) at Blue Hill Meteorological Observatory, Milton, Mass. Lat. 42°12′44″ N., long. 71°6′53″ W., altitude, 635 feet*

[The following abbreviations are used in this table: cld. for cloudy, lt. hz. and d. hz. for light and dense haze, smk. for smoke, v. for visibility (international scale 0–9 with 10 added for visibility greater than 150 km), international (1932) cloud names abbreviations, Beaufort numbers for wind velocity—after wind directions]

Date and hour angle from apparent noon	Solar altitude		Air mass	I_m	I_y	I_r	Sky condition (clouds, haze, visibility, etc.) wind
				gr. cal./min./cm.²			
1933							
Jan. 15:	°	′					
2:28 p.m.	18	03	3.20	1.041	0.778	0.642	Few cld.; lt. hz.; S-3.
Jan. 24:							
3:16 a.m.	18	22	3.14	1.143	.861	.747	Few cld.; hz.; v. 6–7; WSW-5.
0:14 a.m.	28	30	2.09	1.404	.995	.841	Few cld.; hz.; v. 7–8; W-6.
Feb. 6:							
2:27 a.m.	24	01	2.45	1.459	1.045	.868	7 Ci, Cicu; v. 7–8; NW-5.
Feb. 13:							
2:52 a.m.	21	51	2.68	1.178	.855	.732	Few Ci; hz. and smk.; v. 7–8; SSW-5.
0:58 a.m.	32	52	1.84	1.290	.944	.778	Few Ci, Cist, Cicu; hz. and smk.; SW-7.
Feb. 16:							
1:15 a.m.	32	48	1.84	1.404	-------	.830	Few St, few Cu; W-5.
3:24 p.m.	18	48	3.08	1.102	.815	.687	Few Cu; smk.; v. 8–9.
Feb. 21:							
2:15 a.m.	28	54	2.06	1.254	.911	.756	Few Acu; heavy hz.
Feb. 22:							
1:57 a.m.	31	09	1.93	1.333	.973	.796	Few Ci, Cist; hz.; v. 8–9; WNW-4.
Feb. 23:							
1:09 p.m.	37	56	1.62	1.184	.866	.696	1 Cu, fr. cu; hz.; v. 7–8; SW-6.
Feb. 24:							
2:49 a.m.	32	28	1.86	1.184	.874	.706	Few Cist, Cicu, Acu; v. 7–8; W-5.
3:09 p.m.	22	53	2.56	1.130	.852	.706	5 Cu, St cu, fr. Cu; v. 8–9; W-5.
Feb. 27:							
0:07 p.m.	39	26	1.57	1.383	.991	.780	4 Acu; snow flying.
2:07 p.m.	31	44	1.90	1.294	.943	.750	Few Acu; snow flying.
Mar. 5:							
0:54 a.m.	40	13	1.55	1.469	1.021	.826	1 Cu, fr. cu disappearing; v. 9.

TABLE 1.—*Total (I_m) and screened (I_y, I_r) solar radiation intensity (normal incidence) at Blue Hill Meteorological Observatory, Milton, Mass. Lat. 42°12′44″ N., long. 71°6′53″ W., altitude, 635 feet*—Continued

Date and hour angle from apparent noon	Solar altitude		Air mass	I_m	I_y	I_r	Sky condition (clouds, haze, visibility, etc.) wind
				gr. cal./min./cm.²			
1933—Contd.							
Mar. 6.							
3:37 a.m.	21	22	2.72	1.254	0.931	0.768	Few Ci, Cist, Cicu; NNW-5.
2:03 a.m.	34	32	1.76	1.401	1.003	.816	Same as at 3:37 a.m.; v. 9.
0:27 a.m.	41	45	1.50	1.441	1.011	.818	Same as at 2:03 a.m.
0:07 p.m.	42	06	1.49	1.443	1.025	.824	Same as at 2:03 a.m.
1:12 p.m.	39	24	1.57	1.403	.995	.816	2 Ci in S. and W.
Mar. 9:							
2:53 p.m.	29	01	2.06	1.104	.826	.677	2 Cu; v. 8; W-8.
3:38 p.m.	22	02	2.65	.915	.687	.561	Few Ci; v. 8; hz. thickening.
Mar. 10:							
3:07 a.m.	27	13	2.18	1.224	.905	.738	1 Ci, Cicu; v. 9; W-7.
Mar. 11:							
3:15 a.m.	25	35	2.31	1.363	.965	.804	Few cld.; hz. to 10°; v. 10; W-6.
2:04 a.m.	36	10	1.69	1.463	1.017	.848	V. 10.
1:27 a.m.	40	03	1.55	1.483	1.049	.840	Few cld.; v. 10.
0:27 p.m.	42	41	1.45	1.483	1.039	.830	Few Ci, Cicu; v. 10; W-6.
2:55 p.m.	28	35	2.08	1.335	.929	.756	Few Ci, Cicu; smk. and hz.; W-6.
Mar. 16:							
3:27 a.m.	25	58	2.28	1.313	.951	.780	Few Cu, fr. cu; NW-5.
2:55 a.m.	30	48	1.95	1.393	1.019	.832	Few Ci, Cu; v. 10.
2:00 a.m.	38	22	1.61	1.458	1.061	.858	Same as at 2:55 a.m.
1:08 a.m.	43	27	1.45	1.461	1.051	.876	Same as at 2:55 a.m.
0:16 p.m.	45	54	1.39	1.512	1.091	.882	Few Ci, Cist, Cu, fr. cu; v. 10; W-5.
1:10 p.m.	43	18	1.45	1.496	1.085	.876	Few ² Cu; v. 10; W-5.
2:48 p.m.	31	59	1.88	1.377	1.031	.830	Same as at 1:10 p.m.
4:12 p.m.	18	24	3.14	1.136	.886	.722	Lt. hz.
Mar. 17:							
0:16 a.m.	46	18	1.38	1.370	.950	.772	Few Acu; hz.; v. 7; SW-6.
0:28 p.m.	46	00	1.39	1.349	.974	.775	
Mar. 24:							
2:19 a.m.	38	44	1.60	1.271	.862	.731	Few cld.; some hz. and smk.; v 10; NW-3.
0:40 a.m.	48	05	1.34	1.424	1.014	.819	Few Cicu, 1 Cu; NW-4.
0:09 p.m.	49	12	1.32	1.457	1.035	.825	
0:16 p.m.	49	04	1.32	1.443	1.034	.829	
2:08 p.m.	40	09	1.55	1.363	.985	.806	2 Cicu; NE-2.
3:38 p.m.	26	32	2.24	1.174	.905	.734	Few Ci, Cicu, Acu, 1 Cu, St cu; NE-2.
Mar. 25:							
0:38 a.m.	48	44	1.33	1.443	1.033	.826	Few Cicu; NE-2–3.
0:14 a.m.	49	30	1.31	1.435	1.015	.820	Same as at 0:38 a.m.
Mar. 27:							
3:05 p.m.	32	49	1.84	1.236	.876	.722	Ci, Cu, (sun clear); NE-3.
4:01 p.m.	23	25	2.51	1.075	.812	.671	Ci, Cu, (sun clear).
Mar. 29:							
0:53 a.m.	49	25	1.31	1.273	.901	.755	1 Cu, fr cu; v. 8; NW-6.
Mar. 30:							
1:32 a.m.	46	25	1.38	1.430	1.010	.819	V. 10; WNW-6.
0:19 p.m.	51	20	1.28	1.448	-------	.818	Few Acu; v. 10; NW-7.
2:05 p.m.	42	23	1.48	1.368	-------	.810	Few Ci; v. 10; NW-7.
3:09 p.m.	33	01	1.83	1.330	.960	.770	Few Ci, Cist; v. 10; NW-7.
Apr. 5:							
2:58 a.m.	36	38	1.67	1.260	.923	.751	Few Cu, fr cu; lt. hz.; v. 8; W-5.
2:06 a.m.	44	21	1.43	1.374	.962	.786	St cu; sky clear and blue; W-5.
0:53 a.m.	51	56	1.27	1.454	1.012	.822	Same as at 2:06 a.m.
0:26 p.m.	53	20	1.25	1.454	1.012	.820	Same as at 2:06 a.m.
3:19 p.m.	32	55	1.87	1.297	.939	.758	Clear; hz.; WNW-7.
4:48 p.m.	17	23	3.31	1.063	.818	.667	Few Ci in W; W-6.
Apr. 9:							
0:45 a.m.	54	00	1.24	1.408	1.000	.788	2 Ci, few Cu; W-6.
Apr. 10:							
2:17 a.m.	44	22	1.43	1.360	.982	.750	Few Ci, Cu; NE-3.
1:19 a.m.	51	35	1.27	1.384	.990	.778	Cu on horiz; ENE-3.
0:49 p.m.	54	05	1.24	1.404	.988	.778	Few Ci, and Cu; NE-2.
Apr. 11:							
3:00 p.m.	38	00	1.62	1.322	.970	.768	Few Cu; ENE-5.
Apr. 20:							
0:39 a.m.	58	09	1.18	1.398	.966	.792	Few Ci, Cu; lt. hz.; NE-5.
0:16 p.m.	59	07	1.17	1.390	.970	.790	Same as at 0:39 a.m.; v. 7–8.
Apr. 21:							
3:41 a.m.	33	32	1.81	1.258	.901	.741	Few Ci in W; sharp smk. line; W-2.
2:56 a.m.	41	16	1.73	1.309	.914	.741	
1:24 a.m.	54	34	1.23	1.360	.922	.760	2 Ci, in W; Ci- hz. over sun; SW-2.
0:22 p.m.	58	46	1.17	1.386	.964	.780	Thin Cist W to S; hz. to 8°; v. 0–1
Apr. 22:							
3:09 a.m.	39	19	1.58	1.384	.964	.788	2 Ci, Cist, Acu, Ast; N-5.
Apr. 24:							
3:56 a.m.	31	26	1.92	1.267	.882	.738	Few Cist in E.; hz. to 10°; W-6.
1:05 a.m.	51	27	1.19	1.302	.931	.748	Cist in E.; hz. to 10°; W-7.
0:23 p.m.	60	14	1.15	1.322	.931	.756	Few Cist, Acu; hz. to 10°; W-7.
4:20 p.m.	27	03	2.20	.943	.740	.615	Few Cu, Acu; hz. to 13°; W-6.
Apr. 28:							
2:45 a.m.	44	46	1.42	1.387	.995	.788	2 Cist, Cicu; hz. to 8°; SW-3.
0:58 a.m.	59	17	1.17	1.407	1.011	.802	
0:19 p.m.	61	39	1.13	1.358	.967	.780	Few Cist in W.; hz. to 7°; S-3.
May 4:							
2:30 a.m.	48	35	1.33	1.428	.995	.792	Few Cu; lt. hz.; v. 9; NW-6–7.
1:19 a.m.	58	46	1.17	1.445	1.002	.796	Few Cu; lt. hz.; NW-7.
0:48 p.m.	61	49	1.13	1.466	1.004	.798	Same as at 1:19 a.m.
2:26 p.m.	49	14	1.32	1.390	.962	.773	Few Cu; lt. hz.; v. 9; NW-6–7.
5:03 p.m.	21	08	2.76	1.107	.836	.685	Hz.; v. 9; NW-6–7.
May 7:							
0:20 p.m.	64	10	1.11	1.540	1.068	.843	Few Cu; hz. to 5°; NW-6.
May 9:							
0:41 a.m.	63	36	1.11	1.410	.996	.788	2 Ci, Cist, Acu, fr. cu; V. 7–8; SW-3.
0:06 a.m.	65	07	1.10	1.440	1.004	.779	
May 12:							
1:07 a.m.	63	03	1.12	1.202	.873	.682	10 Ci, Cist; ENE-8.
3:59 p.m.	35	04	1.74	.847	.658	.581	1 Ci, few Cu; hz.; ENE-4.

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Date and hour angle from apparent noon	Solar altitude	Air mass	I_m	I_y	I_r	Sky condition (clouds, haze, visibility, etc.) wind
			gr. cal./min./cm.²			
1933—Contd.						
May 15:						
1:19 a.m.	61 40	1.13	1.353	0.954	0.748	Few Cicu, Cist, Cu, Frcu, lt. hz., v. 9; WNW-7.
May 16:						
3:12 p.m.	43 29	1.45	1.314	.926	.724	1 Cicu, Cist, lt. hz.; S-2-3.
May 17:						
0:19 a.m.	66 46	1.09	1.400	.968	.769	Few clds.; hz. to 6°; N-3-4.
0:16 p.m.	66 52	1.09	1.389	.964	.765	Same as at 0:19 a.m.
3:05 p.m.	45 00	1.41	1.261	.932	.716	Few clds.; hz.; v. 6-7; N to E, variable.
4:26 p.m.	41 07	1.52	1.089	.820	.610	Same as at 3:05 p.m.
May 18:						
4:06 a.m.	44 55	1.74	1.236	.909	.722	Few clds.; hz. to 3°; W-3.
1:42 a.m.	59 45	1.16	1.366	.968	.760	Few clds.; hz. to 5°; v. 6-7; W-2.
0:52 p.m.	64 50	1.10	1.342	.939	.741	
2:16 p.m.	53 29	1.25	1.300	.937?	.730	Few Cunb in W; hz. to 6°; SW-3.
May 19:						
3:48 a.m.	37 22	1.64	1.157	.830	.662	Few Ci, Acu; hz. to 10°; v. 6-7; WSW-3.
4:42 p.m.	27 15	2.18	.886	.667	.520?	Few ACu; hz. to 15°; v. 7; SW-6.
May 22:						
3:37 a.m.	39 46	1.56	1.138	1.000	.781	1 Cist.; WNW-2.
2:53 a.m.	47 33	1.37	1.419	.996	.779	
May 24:						
3:40 a.m.	39 29	1.57	1.070?	.765?	.607	7 Cicu, Cist; d. hz. to 12°; v. 6; NW-3.
June 2:						
4:06 a.m.	35 39	1.71	1.160	.835	.685	Few Ci, Cicu, Cist; d. hz.; to 10°; v. 5-6; NW-2.
0:16 p.m.	69 42	1.06	1.454	1.019	.803	Few Ci in W; 1 Ci in S and SE; hz. to 6°; v. 9; NW-3.
2:02 p.m.	57 33	1.18	1.443	1.015	.796	Few Ci, Cist, Acu; hz. to 4°; v. 9; W-1.
4:05 p.m.	35 47	1.71	1.297	.933	.739	Few Ci in W; hz. to 3°; v. 9; W-SW-3.
June 3:						
5:33 a.m.	19 38	2.93	.967	.742	.611	Few clds.; hz. to 5°; v. 6-7; SW-5.
2:34 a.m.	52 14	1.27	1.204	.850	.670	5 Ci; hz.; v. 5-6; SW-5.
0:53 p.m.	67 14	1.09	1.278	.893	.696	Few Ci, Cist; hz.; v. 7; WSW-7.
2:04 p.m.	57 23	1.19	1.215	.857	.653	Few Cu; v. 7-8; WSW-7.
June 4:						
2:20 a.m.	54 56	1.22	1.239	.861	.677	2 Acu, Ast; lt. hz.; v. 7-8; NE-4-5.
0:26 a.m.	69 27	1.07	1.419	.965	.748	1 Clst; v. 8-9; NE-6.
2:53 p.m.	49 10	1.32	1.295	.913	.707	2 Ci, Cu; lt. hz. to 4°; v. 9; E-3.
June 7:						
0:48 a.m.	68 06	1.08	1.117	.783	.622	7 Acu, St cu, Cu; hz.; v. 6; S-2.
June 8:						
2:22 a.m.	54 38	1.23	1.186	.854	.666	Few Ci; Smk. hz., to 5°; v. 5-6; W-1.
1:40 a.m.	61 29	1.14	1.180	.825	.644	Few Ci, Cicu:, hz., smk.; WSW-2.
0:36 a.m.	69 15	1.07	1.213	.857	.670	Few Ci, Cicu; hz. to 7°; W-2.
0:30 p.m.	69 38	1.06	1.213	.838	.644	Few Ci, Cicu, Cist; hz., smk.; W-2.
June 9:						
3:04 a.m.	47 16	1.36	1.156	.818	.640	Few Cist in N; hz.; w 6-7; var.-1.
1:24 a.m.	64 04	1.11	1.215	.844	.657	Few Cicu; hz.; v. 6; SSE-2.
0:23 p.m.	70 08	1.06	1.234	.855	.661	Few clds.; hz. to 4°; v. 6-7.
2:56 p.m.	48 50	1.32	1.107	.785	.618	
4:16 p.m.	33 50	1.79	.943	.707	.553	4 Ci, Acu, Cunb; SSW-5.
June 10:						
1:30 a.m.	63 06	1.12	1.330	.920	.716	3 Ci, Cicu, Cist; lt. hz.; v. 9; WNW-5.
5:28 p.m.	26 56	2.20	1.020	.744	.596	4 Ci, Cicu, Cist; lt. hz.; v. 9; WNW-5.
5:50 p.m.	17 00	3.39	.907	.677	.546	
June 11:						
5:12 a.m.	24 16	2.42	.965	.707	.570	Few Ci; hz. in NW.; v. 7-8; NE-2.
3:27 a.m.	43 28	1.45	1.200	.828	.653	Few cld; hz. SWN; SE-2.
2:39 a.m.	51 56	1.27	1.334	.920	.720	Few cld; hz. in N and W; v. 9; SSW-3.
0:02 a.m.	70 53	1.06	1.351	.926	.729	Few Ci; lt. hz.; S-3.
1:12 p.m.	65 27	1.10	1.347	.926	.733	1 Ci, Cist; hz.; v. 9; SSW-4.
3:15 p.m.	45 28	1.40	1.269	.898	.711	Few Ci; lt. hz.; v. 9; SW-3.
3:22 p.m.	44 11	1.43	1.267	-------	.703	Few Ci; lt. hz.; v. 9; SW-4-5.
4:07 p.m.	35 42	1.71	1.208	.857	.683	
5:28 p.m.	19 11	3.02	.969	.742	.596	Few Ci, Cist, Acu; lt. hz.; SSW-6.
June 12:						
0:25 a.m.	70 17	1.06	1.158	.825	.635	1 Ci, Cist, Acu; WSW-4-5.
June 14:						
4:52 a.m.	27 37	2.15	1.069	.792	.642	Few Ci, Cist, Cicu; hz.; v. 9; NW-3.
3:18 a.m.	45 00	1.41	1.217	.870	.696	1 Ci, Cicu, Cist; v. 6-7; N-3.
2:57 a.m.	59 11	1.17	1.202	.872	.609	
June 15:						
5:33 a.m.	22 04	2.64	1.057	.812	.660	Few cld.; hz.; v. 9; NW-3.
2:49 a.m.	50 33	1.29	1.319	.922	.739	4 Cu; v. 9; NW-3.
June 18:						
5:34 a.m.	20 10	2.88	.996	.760	.620	2 Ci, Cist, Acu; v. 9; NW-4.
June 19:						
5:24 a.m.	21 58	2.65	.835	.651	.535	Few Cicu, Cist, Acu; v. 9; NW-6
June 20:						
0:49 a.m.	68 40	1.07	1.318	.943	.744	1 Ci, Cicu, Cist; NNE-1.
0:14 a.m.	71 01	1.06	1.403	.972	.770	1 Ci, Cicu, Cist; NNE.
0:14 p.m.	71 01	1.06	1.356	.939	.742	
June 22:						
2:14 a.m.	56 33	1.19	1.176	.811	.640	3 Ci, Cicu, Cist, Acu, fr. cu; hz.; v. 6-7; WNW-2.
1:38 a.m.	62 23	1.13	1.204	.825	.651	8 Ci, Cicu, Acu, Cu, fr. cu; WNW-5.
June 23:						
5:32 a.m.	20 31	2.84	1.024	.774	.633	1 Ci, Acu; hz.; v. 8; NW-5.
0:40 p.m.	69 31	1.06	1.436	1.011	.783	3 Ci, Cicu; v. 9; WNW-5.
0:55 p.m.	68 03	1.08	1.430	1.000	.783	
1:24 p.m.	64 25	1.11	1.414	0.983	0.781	
4:24 p.m.	32 57	1.84	1.215	.887	.705	Few Ci, Cist; lt. hz.; v. 9; NW-3.
5:38 p.m.	19 26	2.99	1.067	.833	.653	Few Cicu, St cu; WNW-5.
1933—Contd.						
June 24:						
5:27 a.m.	21 35	2.70	1.087	.820	.661	Few Ci, St cu; hz.; N-1.
2:39 a.m.	52 21	1.26	1.221	.868	.685	Few Acu; d. hz. over Boston; S.&W.-2.
0:33 p.m.	70 03	1.06	1.206	.868	.694	2 Acu, Cu.
4:15 p.m.	34 36	1.76	1.042	.763	.624	Few Acu, thin Cist; SSW-6.
June 27:						
3:59 a.m.	37 23	1.64	.965	.711	.575	3 Cist, Cu; v. 5-6 W, NE, 6-7 S; S-3.
July 12:						
0:29 a.m.	68 52	1.07	1.244	.881	.731	Few Cu; hz.; v. 7-8; NE-4.
1:07 p.m.	65 23	1.10	1.290	.937	.764	Few Cu; v. 7-8; NE-4.
1:51 p.m.	59 14	1.17	1.244	.908	.739	
3:59 p.m.	36 41	1.67	1.103	.801	.636	Few Cu; v. 8-9; NE-5.
4:20 p.m.	32 48	1.84	1.046	.790	.627	Same as at 3:59 p.m.
5:17 p.m.	22 18	2.62	.901	.683	.583	Clds. same as at 3:59 p.m.; NE-4.
July 13:						
4:00 a.m.	36 25	1.68	1.005	.780	.628	Few Cicu; lt. E wind.
3:11 a.m.	45 24	1.40	1.169	.827	.671	V. 9; E-2.
1:40 a.m.	60 48	1.14	1.256	.857	.690	Few Cicu; E-2.
0:10 a.m.	69 30	1.06	1.277	.892	.712	Few Ci, few Cu; SSE-2.
0:50 p.m.	67 05	1.09	1.214	.849	.669	Same as at 0:10 a.m.; S-2.
2:10 p.m.	56 04	1.20	1.181	.822	.644	Few Cu; hz.; v. 7-8; S-E. variable.
3:43 p.m.	39 33	1.57	1.112	.800	.624	Few C; hz.; v. 7-8; SE-3.
5:23 p.m.	21 45	2.69	.993	.725	.575	Few Ci, Cu.
July 14:						
3:34 a.m.	41 13	1.52	1.182	.842	.666	Few Acu; SE.
3:03 a.m.	47 11	1.36	1.203	.854	.674	
1:30 a.m.	62 07	1.13	1.279	.888	.701	Same as at 3:34 a.m.
0:01 a.m.	69 27	1.07	1.314	.918	.712	Few Ci; E.
1:31 p.m.	62 02	1.13	1.320	.924	.733	Few Ci; ESE.
1:51 p.m.	59 00	1.17	1.302	.894	.707	
3:58 p.m.	36 41	1.67	1.163	.842	.668	Few Ci, Cu; ESE.
5:21 p.m.	21 27	2.72	.963	.733	.590	Few Ci, Cu.
July 18:						
2:42 a.m.	50 04	1.30	1.264	.893	.699	Few Ci; hz.; SW-2.
2:07 a.m.	55 49	1.20	1.286	.908	.707	
0:05 a.m.	68 47	1.07	1.366	.950	.729	Few Cu; v. 8; WSW-5-6.
3:43 p.m.	39 15	1.58	1.211	.871	.663	Few Ci, few Cu SE; WSW-5-6
Aug. 6:						
0:34 a.m.	63 28	1.12	1.445	.990	.780	Few St, cu, fr. cu; lt. hz.; N-4.
1:35 p.m.	57 24	1.19	1.450	1.012	.780	4 Ci, 1, St, Cu; lt. hz; v. 9.
2:37 p.m.	47 56	1.34	1.378	.954	.740	2 Ci, St, Cu; lt. hz.; NE-3.
3:19 p.m.	40 39	1.53	1.307	.919	.716	Few Ci; v. 9.
Aug. 7:						
1:38 a.m.	56 43	1.19	1.338	.923	.718	3 Ci, Cist, St, Cu; lt. hz.; S-2.
Aug. 9:						
0:42 p.m.	62 09	1.13	1.369	.910?	.734	Few St, Cu; v. 9-10.
1:28 p.m.	57 35	1.18	1.365	.919	.736	Sky clear.
5:44 p.m.	13 30	4.22	.820	.629	.508	Sky clear; v. 9.
Aug. 11:						
1:50 a.m.	54 11	1.24	1.360	.923	.676	5 Acu, St, Cu; lt. hz.; v. 8.
0:05 p.m.	63 02	1.12	1.334	.917	.702	
Aug. 26:						
4:56 a.m.	18 43	3.10	1.070	.785	.620	Few Ci, Acu; lt. hz. and smk.; v. 9.
5:12 p.m.	15 50	3.63	.879	.669	.513	Cist, 5° from sun.
Aug. 27:						
1:28 p.m.	52 31	1.26	1.066	.772	.600	1 fr. cu, few Acu; d. hz.; v. 6-7; SW-4.
3:00 p.m.	39 17	1.58	1.102	.816	.642	
Aug. 30:						
3:51 a.m.	29 42	2.02	1.304	.939	.746	Few Ci; lt. hz.; v. 9; NW-2.
0:18 p.m.	56 33	1.19	1.387	.955	.755	Few Ci, fr. cu; lt. hz.; v. 9; NW-2.
1:11 p.m.	53 19	1.24	1.383	.966	.742	
3:04 p.m.	37 50	1.63	1.299	.922	.716	
4:03 p.m.	27 33	2.15	1.172	.852	.667	2 Ci, evaporating; v. 9; WNW-1.

TABLE 2.—*Weekly averages of daily totals of solar radiation received on a horizontal surface, as recorded at the Blue Hill Meteorological Observatory of Harvard University, Milton, Mass.*

Week beginning	Gr. cal.	Week beginning	Gr. cal.
Dec. 10, 1932	119	Apr. 23, 1933	470
Dec. 17, 1932	146	Apr. 30, 1933	551
Dec. 24, 1932	89	May 7 1933	498
Jan. 1, 1933	168	May 14, 1933	615
Jan. 8, 1933	129	May 21, 1933	506
Jan. 15, 1933	174	May 28, 1933	426
Jan. 22, 1933	123	June 4, 1933	573
Jan. 29, 1933	217	June 11, 1933	453
Feb. 5, 1933	217	June 18, 1933	558
Feb. 12, 1933	242	June 25, 1933	516
Feb. 19, 1933	253	July 2, 1933	422
Feb. 26, 1933	201	July 9, 1933	509
Mar. [illegible] 1933	341	July 16, 1933	433
Mar. 12, 1933	302	July 23, 1933	495
Mar. 19, 1933	309	July 30, 1933	540
Mar. 26, 1933	377	Aug. 6, 1933	527
Apr. 2, 1933	256	Aug. 13, 1933	349
Apr. 9, 1933	313	Aug. 20, 1933	269
Apr. 16, 1933	383	Aug. 27, 1933	451

NOTE.—In any week in which the record for 1 or more days is incomplete, the sum of the averages for each hour has been adopted as the average daily total for that week.